ARMENIA
COAL RESOURCE EVALUATION REPORT

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EXECUTIVE SUMMARY

The Government of Armenia is in the midst of a reform effort for the power sector. As this work progresses, a strategic power production plan will be developed to ensure integrity of the power production system as well as the ability to deliver fuel to the power stations. This reform effort must recognize the current and future fuel resources required for operation of the power stations whether their source is domestic or imported. Within the strategic planning exercise, it is important to consider the value of strategic domestic fuel resources such that the country has some insurance against external political issues that could disrupt fuel deliveries.

Since 1995, the Ministry of Energy (MoE), with the assistance of USAID has been examining coal resources within Armenia that could be used as an alternative energy source. In 1998, a coal-fired power station was conceptualized; a comparative alternate-source power-generation study is being prepared to examine the economic feasibility of such a plant. Knowledge of Armenian coal suggests the power station be a fluidized bed design because of its tolerance for low calorific value, high ash and sulfur content. Work efforts to evaluate coal resources in Armenia have resulted thus far in enhanced definition of the coal fields, identification of significantly more resource, and a small-scale mining economic study for recently discovered coal. The goal of this effort is to provide Armenia with a significant degree of energy security.

This report is part of the evaluation of coal potential for large-scale generation use. This evaluation does not take into account any other possible coal applications (e.g. small scale, end-use).

ES.1 CONDENSED SUMMARY OF RECOMMENDATIONS

Based on this review, the following actions are recommended:

1. Abandon any further exploration efforts on the Jajur, Nor-Arevik, Jermanis, Antaramut, and Shamut coal deposits as a potential source for power generation.

2. Continue exploration on the Ijevan coal deposit as the only promising source for large-scale economic production.

3. A likely delivered cost of Ijevan coal cannot be determined at this time due to inadequate definition about the coal reserve and its location. As a design characteristic for domestic coal, employ a free-on-board (FOB)-rail Hrazdan price range of $25 to $57 per metric tonne for an as-received basis 4,100 kcal/kg, 50% ash, 5% moisture, 3% sulfur, and dry-ash-free basis 25% volatile matter product.

Analyze a range of delivered prices to establish economic criteria to compare against other power generation alternatives.

4. Recognize that the exploration program, if continued, will embark on even more marginal solid fuel resources. Economic guidelines should be established to allow rational decisions concerning Armenia's ability to support an expensive energy security policy by setting financial limits dependent on Armenia's capability, donor tolerance, and likely private financial interest. This exercise should establish how non-economic or expensive mining ventures would be financed and/or subsidized on an annual basis in order to support the economics of the coal-fired power station.

5. Continue the Armenian Coal Exploration and Resource Assessment Program for Power Generation by establishing maximum fluidized bed fuel characteristics for marginal fuels, such as those with over 50% ash, along with acceptable economic guidelines. Employ these guidelines to conduct a preliminary evaluation of future marginal fuel resources, such as the Dilijan oil shale, to determine if projects meet minimum guidelines established by item number 4 above before commissioning exploration work.

6. Initiate a new research program parallel to any domestic exploration effort to define potential coal producers and coal deposits in the countries bordering Armenia in an effort to develop a mutually dependent relationship that can provide a solid fuel resource to support a mine-mouth or Armenian-sited power plant.

7. Investigate the potential of the Tkibuli coal mine in Georgia as a viable option to generate an alternative solid fuel supply source that can attain energy security goals. It is very important to recognize that this is the only specific solid-fuel energy option currently identified in neighboring countries. Evaluate the option to construct a mine-mouth power station in Georgia and wheel power to Armenia as well as locating a power plant in Armenia with rail haulage of coal. Assess these options in detail to establish a concrete option as a basis of measuring other solid-fuel power generation alternatives. Present this option to the Government of Armenia as a formal energy security option against which all other future options can be compared.

8. Upon successful completion of #4, begin action to create attractive incentives for foreign mining companies and investors by reviewing and establishing new mining industry policies, mining regulations, and environmental guidelines.

ES-2 DISCUSSION OF RECOMMENDATIONS

The Armenian Coal Exploration and Resource Assessment Program to date has only found about one million tonnes of coal (Antaramut) that could be considered as potentially mineable and economical. To support a 50 MW power station for 35 years, it is expected that about 9.5 million tonnes of proven coal reserve is required. The U.S.G.S. recommends that three of the deposits evaluated - Jajur, Nor Arevik, and Jermanis - receive no further attention. These resources contain no significant quantities of economic reserves and it appears appropriate to abandon any further action on these deposits.

The Shamut coal deposit should be better described as a carbonaceous shale deposit with a very low quality resource. Current information suggests that the average heat value of mineable seams is 2,100 kcal/kg, which is extremely low. The seams are erratic, thin, and deposited in such a fashion that it appears it would be very difficult to mine all the individual layers, provide a product with a good heat value, and economically mine the deposit. The potential power station fuel reserve volume requirement, given the low heat value, appears to be high in relationship to the available resource. The resource will likely be greatly discounted as feasible surface mining methods are considered, because the deposit is so thin and vertically fragmented. The variable and thin nature of the carbonaceous shale deposit seams does not appear to be feasible for an underground mining method. Thus, we recommend not pursuing the Shamut deposit any further.

The other deposit, Antaramut, has been fully explored and determined to be capable of providing about one million tonnes of acceptable quality economic coal.

The last deposit - Ijevan - may have potential. Here we find a much thicker seam with a measured section of up to 23 meters. Sample data suggest an in-situ heat content average for the seam in the order of 4,400 kcal/kg (7,920 btu/lb.) and an average for an internal mineable section of 5,500 kcal/kg (9,900 btu/lb.). The deposit is contained within a complex geologic structure dipping down from 45 to 70°. The complex geology and the need for a labor-intensive underground mining method, such as the breast and pillar technique, are negative aspects concerning potential development of the deposit. On the positive side, the deposit is located near local infrastructure, water, and rail. The field has not been explored and the U.S.G.S. is of the opinion that additional resources may well exist. Of all the coal deposits identified in Armenia, Ijevan appears to present the best opportunity to locate mineable reserves. It also appears to be the last identified opportunity for good coal quality and volume at this point in time.

The efforts of the Armenian Coal Exploration and Resource Assessment Program have appropriately focused to date upon locating the best available coal reserves in Armenia. As mentioned above, one candidate, Ijevan, appears to hold promise of a decent quality coal with adequate reserves. Other known remaining domestic solid-fuel resources include the Dilijan oil shale deposit located northeast of the Sevan Lake near the town of Dilijan. Analyzing low-grade fuel deposits any further will require investigating fuel resources with ash content greater than 50%. Ash content greater than this magnitude will likely dictate a mine mouth power station and a much more meaningful ash management plan if ventures are to be economic. We recommend that a maximum technical capability description be prepared for a fluidized-bed power station to guide explorers in evaluating solid-fuel options, such as those with ash greater than 50%, prior to expenditure of further funds for these type projects. Because it will be necessary to evaluate more marginal domestic fuel reserves now, guidelines should also be developed to guide decisions related to economic analysis of fuel resources and power station feasibility. Capital and operating costs for a 50 MW fluidized bed power station given varied ash contents, calorific values, and price assumptions were evaluated at the feasibility level in 1998 and should be updated to allow explorers the capability to evaluate a fuel reserve and to predict likely economic performance of a specific deposit. In this way, likely economics can be reviewed to determine if it is reasonable to pursue further exploration efforts.

The information provided in this report and any subsequent economic analysis relative to a coal-fired power station should be employed to analyze the likely cost of developing a fuel resource. This analysis should be used to determine how expensive or non-economic ventures would be financed and subsidized on an annual basis. This exercise should allow rational decisions concerning Armenia's ability to support an expensive energy security policy by setting financial limits dependent on Armenia's capability, donor tolerance, and private bank interest. Guidelines should be developed for this project to ensure precious donor funds are not poorly employed.

In continuing the Armenian Coal Exploration and Resource Assessment Program from a domestic perspective after Ijevan, it is necessary to evaluate lower marginal fuel resources. It is recommended that a parallel program be implemented to attempt to source better quality solid fuel resources beyond Armenian borders. These resources might provide more energy independence through mutual reliance upon economic goals with Armenia's neighboring countries. Although this alternative is not as desirable as having domestic coal reserves, it is a viable alternative to the current situation with a single source of natural gas. A program of researching information on potential coal suppliers and coal resources in the countries bordering Armenia wherein mutual international economic benefit could result, is recommended. Opportunities to develop a source of supply from a coal deposit or to procure power from a power plant that could be constructed at a foreign coal deposit should be investigated.

The Tkibuli mine in Georgia is a viable option because a mine exists, reserves have been identified, and the Government of Georgia desires to improve the economy in the Tkibuli region. In addition, a transportation system is in place and a situation would exist where dependent reliance between supplier and buyer would act as a long-term cohesive agent. This alternative should be fully investigated, developed, prepared as a formal option, and presented to the Government of Armenia as a viable alternative.

The coal resources identified during the coal exploration program were reviewed to determine a mining cost could be estimated, that is reasonable for the type of domestic reserves identified and appropriate for use in economic analyses for a coal-fired power station. Because adequate information concerning economic coal reserves is not available, this task can not be accomplished with any degree of certainty. Nonetheless, as all reserves identified so far appear to be amenable to a contour-haulback mining method, the costs developed by the U.S.G.S. were used as a reasonable estimate of the likely lower limit of mining costs. We then estimated a range of likely delivered coal prices by using current unit bulk cargo rates for rail.

There is inadequate information to generate reliable cost and fuel quality estimates for confident economic analyses of a 50 MW coal-fired power station. We recommend that a delivered cost, FOB-rail range from $25 to $57 per metric tonne be employed as a cost estimate for domestic coal delivered to a power station at Hrazdan. Because of the lack of sufficient information, a range of mining costs will have to be employed to analyze coal-fired power generation economics against other generation alternatives. Similarly, a theoretical calorific value of 4,100 kcal/kg, an ash content of 50%, a sulfur content of 3.0%, moisture content of 5%, and a DAF[*] volatile matter content of 25% are suggested as the domestic design fuel quality characteristics for a coal-fired power station.

There is a need to qualify exploration programs before they are executed. The analysis of the Shamut and Antaramut deposits are examples that show a mining professional is required to analyze deposits or exploration targets prior to venturing into a project. It is also necessary to have a coal professional evaluate the supply options of providing foreign coal to Armenia and searching for existing producers. It will be of advantage to require an independent mining/power professional to develop new guidelines, analyze new exploration prospects and evaluate solid fuel supply options for the power stations in order to ensure optimization of donor resources.

To date, the focus of this work program has been on the power sector. If solid fuel resources are found in Armenia, it will be necessary to attract foreign investment and satisfy foreign donors. Discussions with foreign mining professionals working in the industry indicate that little has been done to make the mining sector attractive to foreign capital sources or mining companies. In fact, it is difficult to even receive a letter of credit to purchase supplies that must be obtained from foreign sources. Immediate preparation of acceptable regulations and policies for the mining industry is recommended so that foreign mining companies and their financiers can be attracted to Armenia while appropriate environmental safeguards are provided. This work requirement can be made as a condition for continued exploration funding by USAID or any other international donor agency, while the opportunity is present.

ES-3 RECOMMENDED STEPS

A number of next steps are recommended. These include:

1. Request the U.S.G.S. to collect and document all known information available about the Ijevan coal deposit. They should also generate a set of assumptions and conclusions regarding the status of this information and the potential for locating

[*] DAF - Dry Ash Free. This is a method of testing a coal sample wherein all the moisture and ash content have been removed before the sample is tested.

additional coal resources at Ijevan. Use this information to develop an exploration plan.

2. Request a scope of work and cost proposal from the U.S.G.S. to evaluate Ijevan and have the work program and background material reviewed by an independent mining professional. Negotiate the work program, involve the mining professional, and commission the work.

3. Within the Power Generation Alternative Case Evaluation being performed, incorporate a series of alternate coal-fired cases representing the range of mining costs concluded herein to provide a full spectrum of the economic analysis for a series of delivered coal prices.

4. The current Least Cost Generation Plan (LCGP) team should define the maximum coal quality parameters that can be employed in the fluidized bed so that marginal solid fuel deposits, including coal, can be evaluated prior to exploration expenditures. Request an economic model be prepared along with guidelines so explorers can evaluate standard and more marginal solid-fuel reserves.

5. Commission work to establish what economic limits are acceptable relative to pursuing an alternate energy supply. Formally determine what donor and private financing limits are acceptable as well as the capability of the Armenian Government to subsidize the mine and or the power station. Relate this study to the future of the power sector and establish an appropriate set of guidelines.

6. Based on #5, revise any existing solid fuel power generation option as a base case to compare other potential future options against, by fully investigating the potential of using the Tkibuli, Georgia coal mine and deposit as a coal supply source. Evaluate both a mine-mouth and an Armenian sited power station and prepare a formal summary for presentation to the Government of Armenia. If adequate support exists, prepare a formal package for submittal to the Government of Georgia and private investors.

7. Within any international regional assistance efforts, initiate a new parallel solid-fuel resource investigation program by researching the potential of identified mining and coal deposit resources in neighboring countries.

8. Initiate action to revise Armenian mining policies and regulations and to review and revise their environmental standards in the mining sector. Ensure policies, regulations, and standards meet international donor specifications to help improve the likelihood of attracting foreign mining companies and their financiers.

INTRODUCTION

It is prudent to look towards energy security as a means to maintain economic strength and support the capability of Armenia to prosper. One of the avenues being explored at this point in time is the potential to use domestic coal reserves to provide a dependable source of domestic fuel. One of the primary uses of this fuel would be the generation of electric power. Therefore, the capability to supply domestic coal to a coal-fired power station in Armenia is being evaluated to achieve this energy security goal.

Coal has long been known to exist in Armenia, but coal resources paled in contrast to the resources of the Former Soviet Union (FSU) such that in an era of central planning, little attention was paid to the comparatively meager coal resources in Armenia. Coal deposits identified by past exploration efforts were thought to be small and to have relatively thin and discontinuous coal seams. Subsequently, the potential for huge economic coal resources appeared quite remote.

Recently, the United States Geological Survey (U.S.G.S.) under a Participating Agency Service Agreement with the United States Agency for International Development (USAID) has been working with the Armenian Government on the Armenian Coal Exploration and Resource Assessment Program. This program, conducted from 1995 through 1999, consisted of geologic field work and mapping, exploration drilling, coal quality laboratory activities, geophysical logging activities, map production, database creation, resource assessment, and comprehensive training on all aspects of the program. The work concluded, to date, with several results including determination of increased coal resources, identification of new coal resources, and other achievements.

At this point in time, it is necessary to review the work completed to date, and assess the potential coal appears to provide for generating a higher degree of energy independence.

CHAPTER 1
THE NEED FOR COAL-FIRED GENERATION

Currently, Armenia has electricity generation capacity that includes nuclear, hydro and natural gas/mazut fired-power stations. The generation capacity of Armenian power stations, based on the latest Hagler Bailly information, is summarized below (Table 1-1).

Table 1-1
Armenian Power Sector Generation Plants

Plant	Units	Year of Commissioning	Current Installed Capacity MW	Current Available Capacity (estimate) MW
Medzamor Nuclear	2x440	1976, 1980	440	375
Yerevan 1 CHP TPP	5x50	1963 - 1965	200	180
Yerevan 2 Block TPP	2x160	1966 - 1968	320	300
Hrazdan 1 CHP TPP	2x50, 2x100	1966 - 1969	300	200
Hrazdan 2 Block TPP	3x200, 1x210	1971 - 1974	810	810
Sevan-Hrazdan Cascade	7 facilities	1949 - 1961	532	532
Vorotan Cascade	4 facilities	1970 - 1984	400	400
Small Hydros			56	56
Total			3,058	2,853

Nuclear comprises 14%, hydro 33%, and thermal (TPP) 53% of the current available capacity. Hydro plants are the only domestic power production capacity that provides a level of insurance against foreign fuel supply interruption. In theory, hydropower can provide only 33% of total electricity production capacity. However, the reality is that there are several generation restrictions such as water availability and environmental issues related to Lake Sevan. The total generation by fuel type in 1999 consisted of 36% nuclear, 19% hydro, and 45% thermal (Table 1-2).

Table 1-2
1999 Domestic Gross Electricity Generation

	Fuel Type			
Characteristic	Nuclear	Hydro	Thermal	Total
Electricity GWh	2,078	1,074	2,438	5,716
Supply Percentage	36%	19%	45%	100%

Source: Energy Regulatory Commission (ERC)

The forecast developed by the Energy Regulatory Commission (ERC) estimates demand in year 2000 will be slightly higher than 1999 at 5,673 GWh. A system winter peak of about 1,100 MW is expected.

The generating units are generally rather old and may require replacement and/or decommissioning soon. It is generally accepted that the natural gas-fired power stations are relatively inexpensive to build and operate in this part of the world than coal-fired power stations, given projections for natural gas prices and capital costs.

The ethnic and political tension within the region, as is evidenced by the Nagorno-Karabakh, Abkhazia, Ossetia, and Chechnya conflicts, creates a need to protect one's economy from the problems caused by disruption of imports caused by conflicts. For this analysis, the concern is the disruption of the supply of natural gas that would result in a significant loss in the capacity to produce electricity and thereby harm the Armenian economy.

In conclusion, the purpose for constructing a coal-fired power station in Armenia is to replace old capacity while implementing an energy security policy aimed at increasing the insurance Armenia currently has against foreign fuel supply interruptions. Currently, hydro is providing the only domestic source of electricity by satisfying 21% of Armenia's demand for electricity. The remainder of electricity production comes from generation with nuclear fuel and natural gas, both of which are imported.

Assuming a peak demand of 1,100 MW, a 50 MW domestic coal-fired power station would represent less than 5% of the peak demand.

Chapter 2
Coal Resources To Supply Power Stations

The goal of achieving more energy independence for Armenia initiated an effort to evaluate domestic solid fuel reserves with a focus on the coal resources of Armenia. In the past, the coal resources of Armenia were essentially ignored because they were far less important that other Soviet coal resources. In addition, natural gas and mazut were plentiful and relatively inexpensive so marginal coal deposits held less value.

The coal resources of Armenia are found throughout the country in relatively small deposits that to date have been inadequately explored. The coal can be found in occasional outcrops, generally occur in thin seams, and in some cases are mined for fuel. Because the deposits were inadequately explored, USAID enlisted the United States Geological Survey to assist Armenia in defining these resources. The hope for this effort was identification and location classification of any promising coal reserves.

In the mining sector, coal or similar mineral of potential value that is found initially is simply defined as a resource. As more information is gathered to define the extent and utilization of the deposit it becomes classified by distinctions which indicate the economic mineability and quality of the mineral in the market place. The Russian and U.S. systems used for this purpose are similar in that they strive to develop the information necessary to define the mineral deposits in a fashion that addresses quality, volume, and economic issues. One primary difference between the two systems is the definition of economic reserves.

In the case of Armenia, few of the coal resources have been identified as economic reserves. Generally speaking, in non-technical terms, resources are considered as mineral resources that are uneconomic or are inadequately defined to establish if they could be economic or marketable. Reserves are defined as resources that have been defined as mineable and economic and provide the mine with an inventory of mineral that can be mined and sold in the future for economic profit.

Coal resources in the U.S. employ the U.S.G.S. classification system to define reserves into four prominent classifications roughly correlating to the Soviet system of reserve classifications, as shown in Table 2-1. In the U.S. coal industry, the U.S.G.S. classification system is used to define the economic reserves that a mine can confidently rely on for decisions regarding mine construction, development, and economic decisions. It is commonly accepted that in order to support investments in feasible mining projects that reserves must be classified as demonstrated. This includes the sub-classifications of measured and indicated noted in Table 2-1. Therefore, in order to consider reserves as potentially mineable and economic, they must be classified as A, B, or C1 reserve classifications in the Soviet system.

Table 2-1
Comparison of U.S.G.S. and Armenian Coal Resource Classification Systems

System	Classifications					
Soviet	A	B	C1	C2	P1	P2
U.S.G.S.	Measured		Indicated	Inferred	Hypothetical	

2.1 COAL RESOURCES OF ARMENIA

The USGS[1] analyzed the coal resources of Armenia and provided the summary in Table 2-2 as defined by Soviet resource classification standards. The information above shows that there is potential for up to 147 million tonnes of coal resources to qualify as coal that could possibly provide for economic coal reserves to support a coal-fired power station. However, as mentioned above, the categories that should be focused upon here are the A, B, and C1 classifications. The identified coal resources in these classifications are estimated at 6,001,000 tonnes plus any of the Shamut C2 coal resources that could possibly be classified as a C1 classification type. These data only indicate that coal exists as a resource that might be economic so they must be analyzed to determine how much, if any, of the coal can be economically mined.

Table 2-2
Soviet Classification of Coal Resources in Armenia
Thousands of Metric Tonnes

	Coal Tonnes by Resource Classification						
Coal Deposit	A	B	C1	C2	P1	P2	Total
Antaramut (4)	1,416		4,102	26,079			31,597
Shamut (1)			4,055		10,592		14,647
Ijevan (2)				9,780	88,000		97,780
Jajur (1)	483						483
Nor Arevik				23			23
Jermanis (3)					2,251		2,251
Total	1,899		44,039		100,843		146,781

Note:
(1): USGS Recalculation of Resources based upon Armenian geologic data.
(2): Armenian Officially Reported Resources.
(3): The classification of this resource was not defined within the USGS reports. We classified the reserves as P because seams are lenticular and thin, <0.5m, and poorly defined.
(4): Based on the economic mining study and C1 resource reported by the USGS, we have classified the total tonnage estimated by USGS in the categories shown.

[1] Coal Exploration and Resource Assessment of Armenia, U.S. Geological Survey Open-File Report 99-567; Brenda S. Pierce, p. 4-9

Of these coal resource deposits, that U.S.G.S. recommends (in the text referenced above) that Jajur, Nor Arevik, and Jermanis not be pursued any further as candidates to find additional coal reserves. These U.S.G.S. recommendations are provided below:

Jajur:

> "Localized drilling is needed to restart and expand the small mining operation (the sited of a USAID-funded strip mine), if continued mining is desired. The Jajur deposit may be an important local resource, especially for use in Gyumri. However, larger scale regional exploration is probably not warranted."

Nor Arevik:

> "Detailed field work and geologic mapping by USGS indicate that the Nor Arevik coal field is sufficiently understood. Because net thickness is not great and the aereal extent of the coal probably does not extend much beyond that already studied, the Nor Arevik coal deposit can probably be considered a local resource. No further exploration is recommended."

Jermanis:

> "Detailed field work and geologic mapping by USGS indicate that the Jermanis coal field is not very laterally extensive and occurs in a fairly structurally complex area. In addition, net coal thickness is not great. The Jermanis coal field can be considered a local resource. No further exploration is recommended."

These conclusions indicate that the three coal deposits are inadequate for power generation. There are insufficient volumes of coal available in these deposits to support a coal-fired power station. Hence, each of the remaining deposits (Antaramut, Shamut, and Ijevan) need to be examined separately in order to understand the potential each deposit has to offer.

2.2. ANTARAMUT COAL RESOURCE ASSESSMENT

The Antaramut coal deposit is located about 15 kilometers north-northeast of the town of Vanadzor in north central Armenia. The topography in the vicinity of this coal deposit is hilly as shown in Figure 2-1, below. Here, the U.S.G.S. took a coal deposit that was expected to contain insignificant coal resources and identified a coal deposit containing a significant coal resource. Prior work conducted by geological professionals concluded that there was little coal and the resource volume was not calculated. The USGS work product projects a coal resource of about 32 million tonnes, as shown above in Table 2-1. The exploration also successfully identified an area of the deposit wherein it is very likely that economically mineable coal resources exist. Although additional development drilling is necessary to confirm the coal reserve assumptions, it appears that 1.4 million tonnes of coal could be recoverable and economic if additional drilling confirms the reserve quantity and quality.

Figure 2-1
Antaramut Deposit Area Topography

According to the U.S.G.S.[2] the coal at Antaramut is of Upper Eocene age and is primarily contained within two coal beds, each about 1 meter thick. Analysis of drill hole information shows seam thickness generally ranging from 0.8 to 1.3 meters but occasionally as high as 1.8 meters. The coal is of high-volatile bituminous rank. The estimated quality of the coal, as determined from U.S.G.S. data, is shown below in Table 2-3.

Studies by the U.S.G.S. indicate that this coal can likely be beneficiated with the ash content being reduced from 40% down to a level of 20 to 25%.

A pre-feasibility study conducted by the U.S.G.S. was completed for the 1.4 million tonne portion of the coal reserve. This pre-feasibility study provides a cost estimate of developing this particular coal deposit in Armenia which can be used as a basis for cost estimation for coal deposits which could employ a contour haulback mining method complemented by an auger mining method. This study concludes that the recoverable economic coal reserve is estimated to be 916,000 tonnes.

[2] Coal Exploration and Resource Assessment of Armenia Program, Implemented by the U.S. Geological Survey, Funded by the U.S. Agency for International Development In Cooperation with the Republic of Armenia Ministry of Environment, Brenda S. Pierce, p. 47-54.

Table 2-3
Antaramut Coal Sample Quality Characteristics

Quality Parameter	Units	Upper Bed	Lower Bed
Calorific Value – Moist Mineral Matter Free Basis	Kcal/kg	7,800	8,600
Ash Content – As Received Basis	%	43	41
Moisture Content	%	5.2	4.9
Sulfur Content	%	3.2	2.8
Calorific Value – As Received Basis	Kcal/kg	4,250	4,630
Volatile Matter – Dry Ash Free Basis	%	24.7	26.5

The coal resources provided by U.S.G.S. in Table 2-2 indicate 4.1 and 26.0 million tonnes of C1 and C2 class coal, respectively, within the Antaramut coal resource. The coal dips away from the ground surface in the north at about 15° to the south while topography and layers of earth, or overburden, overlying the coal increase towards the south. This combination of decreasing coal elevation along the dip coupled with the increasing elevation of the ground surface overlying the coal creates a coal resource that has very limited potential for economic surface mining. Given the structural environment within which this coal exists, most of the Antaramut coal resource would have to be mined using underground mining techniques. These techniques are not expected to be economically feasible because the seams are too thin and inconsistent for efficient underground mining.

The portion of the coal reserve where it outcrops at the surface was included in the pre-feasibility study conducted by the U.S.G.S. The potential for economically mineable reserves for the Antaramut coal deposit are assumed to be about 900,000 tonnes. It should be mentioned that there is a small section of coal in the southeastern portion of this deposit which does outcrop, possibly providing some additional coal reserve potential but it is likely to contribute a small quantity, if any, to the reserve potential.

In summary, the potential for economically mineable reserves at the Antaramut deposit is assumed to be about 900,000 tonnes of coal. There is other coal resource in this deposit but it is unlikely that the coal is cost effective because it is too thin for economic underground mining and has limited surface mining potential. No further work at the Antaramut deposit is recommended.

2.3 SHAMUT COAL RESOURCE ASSESSMENT

The Shamut coal deposit is located about 30 kilometers northeast of the town of Vanadzor in north central Armenia. The deposit is located just north of the Martsiget River. The topography of the Shamut site is rolling hills as can be seen in Figure 2-2.

Figure 2-2
Shamut Deposit Area Topography

The coal bearing section, according to prior geologic reports, includes three primary beds that continuously extend over a length of 4 kilometers from the village of Shamut east to the village of Atan. The resource calculations of 14.6 million tonnes made by the U.S.G.S.[3] includes everything with coal as described by geologists during logging exercises, only ignoring slightly carbonaceous beds. In this calculation, there was no minimum bed thickness or maximum ash criteria established. This calculation thus represents a true resource calculation and must be analyzed in depth for mineability and economic realities. The Shamut deposit contains beds that should be properly described as carbonaceous shale beds rather than coal beds because the ash content in the beds is greater than 50%. The deposit is, therefore, more accurately described as the Shamut coal and carbonaceous shale deposit when considering the resource calculations referenced above in Table 2-2.

The referenced reserve report by the U.S.G.S. does not provide any summary details to allow inspection of the thickness of the coal/carbonaceous shale seams or the relative quality resulting from the calculation of the total resources. By employing Table 8 of the referenced report, some information on the three primary seams identified for the resource can be discerned. These seams are defined by the U.S.G.S. as the upper, middle, and lower beds. This data is representative of sixteen separate sampling points through the resource area. The information has been recast on a bed (or seam) basis in Table 2-4.

[3] The Shamut Coal Deposit, North-Central Armenia by Brenda S. Pierce, Gourgen Malkhasian, and Artur Martirosyan, Advance Copy of a U.S. Geological Survey Bulletin which is as of yet un-numbered. Table 15.

Table 2-4
Characteristics of the Coal and Carbonaceous Shale Beds
Shamut Deposit

Seam	Thickness Meters	Calorific Value (a)	Calorific Value (b)	Moisture % (c)	Ash % (c)	Sulfur % (c)	Volatile Matter % (c)
Upper Bed							
Average	1.45	5,303	2,132	4.39	57.95	1.25	48.97
Minimum	0.78	4,478	1,604	1.17	40.69	0.40	40.00
Maximum	3.93	6,800	3,896	8.89	63.45	3.12	53.72
Middle Bed							
Average	1.22	5,536	2,265	4.70	57.07	1.00	49.59
Minimum	0.81	3,255	886	0.94	43.30	0.35	41.77
Maximum	1.45	6,969	3,914	8.34	71.34	1.90	60.14
Lower Bed							
Average	1.63	4,881	1,783	3.62	62.10	1.34	53.39
Minimum	0.34	4,012	1,164	1.30	53.12	0.29	50.00
Maximum	4.20	6,377	2,870	7.73	68.56	3.00	58.77
All Beds (d)							
Average	1.42	5,270	2,083	4.29	58.71	1.19	50.27
Minimum	0.34	3,255	886	0.94	40.69	0.29	40.00
Maximum	4.20	6,969	3,914	8.98	71.34	3.12	60.14

Note:
a: Dry – Ash Free Basis (As reported by U.S.G.S. review of Armenian data).
b: As-Received Basis, our calculation.
c: Dry Basis
d: Average of all Data Points.

This information shows that the deposit should be classified as a carbonaceous shale deposit because the average ash content is about 59%. The deposit shows an indication of low moisture and sulfur content, at 4.3 % and 1.2%, respectively. The average as-received calorific value is estimated at about 2,100 kcal/kg, which is about equivalent to 3,800 btu/lb.

The coal section was analyzed to determine a likely mining section. This work shows the mining section is highly variable and includes several non-carbonaceous layers requiring removal to maintain the typical quality values shown above, even without considering dilution from mining operations. Table 2-5 shows two drill hole sections of the mining zone that display the range of layers requiring selective mining during the mining process. The minimum thickness one would desire to work with from a surface mining perspective is at least 30 centimeters. It can be seen in the table below that it is difficult to add carbonaceous and non-carbonaceous layers together to form a mineable zone without adding significant ash into a mineable section. It can also be seen that carbonaceous layers occur that can not be mined because they are too thin.

The same principle applies to some non-carbonaceous layers that can not be removed from between two carbonaceous layers because the resultant mining section would have more ash than the ash content of the two seams combined. In essence, it is difficult to mine all the multiple layers of carbonaceous and non-carbonaceous materials because of the thickness of the individual layers involved. It would also be more expensive to mine the deposit in this fashion if several selective mining operations were required to produce a run-of-mine product with ash content as low as possible from the reserve. We have assumed that a maximum of 70% in-situ ash is acceptable as mining sections in Table 2-5 were selected.

There are samples of coal within the resource indicating that true coal beds with ash below 50% do exist. Analyses of these individual samples show an average thickness of 0.4 meters and an average ash content of 41%. If this coal could be selectively mined, the ash content would increase by dilution caused by the mining process. In addition, many of the sampled sections could not be mined individually and should be mined in a thicker section with other coal containing layers.

In summary, in order to develop adequate quantities of fuel for a power station, a larger vertical mining section of coal must be mined. The ash within the section mined will increase to the point where this resource then would, on the whole, produce a very low quality carbonaceous shale, much like or worse than that shown in the summary in Table 2-4.

It can be seen from Table 2-5 that the only feasible underground mining section is the middle coal/middle coal shale section, measured at 1.7 and 1.2 meters thick in drill holes 8/53 and 9/53, respectively. This is the only underground mining section that could possibly produce a product with an ash that is reasonable. It can be seen that both the thickness and the ash content within this section varies greatly, from 1.2 to 1.7 meters and from 44 to 54% ash, respectively, just between these two sample points. It can be seen by comparing this mineable underground thickness to the total carbonaceous shale thickness of 2.8 to 3.4 meters, that a reduction in the mineable section would reduce the mineable resource thickness, and thus the available mineable resource, by 40 to 50%. The thickness of the middle carbonaceous layer is not consistent and generally is less than one meter thick, relative to a mineable section. A quick audit of the coal thickness of likely mining sections shows the coal seams change frequently in quality and thickness. It is doubtful that a reasonable mining section height could be established within the reserve in order to mine this material with underground methods while producing a reasonable ash product.

This deposit could be best mined by surface mining techniques calling for initiation of mining at the crop and progressing with individual pits either perpendicular or parallel to strike. This technique would develop a higher quality product with values possibly similar to those shown in Table 2-4. Prior studies on coal washability do not provide a reliable guide; thus, it is undetermined if beneficiation[4] may result in a significantly lower ash product.

Table 2-5
Shamut Typical Mining Sections

Drill Hole 8/53				Drill Hole 9/53			
Layer Description	Thickness Meters	Mining Zone	Ash % (1)	Layer Description	Thickness Meters	Mining Zone	Ash % (1)
Upper Coal Shale	0.50	1	52%	Upper Coal Shale	0.38	1	58%
Sandstone	0.74			Argillaceous Sandstone	0.89		
Middle Coal Shale	0.19		51%	Middle Coal	0.41	2	52%
Clayshale	0.09			Argillaceous Sandstone	6.06		
Middle Coal Shale	0.23		55%	Lower Coal	0.09		29%
Sandstone	0.55			Argillaceous Sandstone	1.08		
Middle Coal Shale	1.70	2	54%	Middle Coal	1.20	3	44%
Sandstone	0.09			Argillaceous Sandstone	0.55		
Lower Coal Shale	0.09		65%	Lower Coal Shale	0.50	4	54%
Sandstone	0.37			Argillaceous Sandstone	2.41		
Lower Coal Shale	0.19		51%	Lower Coal Clayshale	0.24		57%
Lower Coal Clayshale	0.46		75%				
Total Carbonaceous Shale	3.36				2.82		
Total Mining Section Thickness	2.30				2.49		
Total non-Carbonaceous Shale	1.84				10.99		

Note:
1: As Received Basis

The resource estimate for Shamut projects a maximum of 14.7 million tonnes for the current strike length assumption of four kilometers. This estimate includes sections of non-mineable layers. With an average calorific value of 2,100 kcal/kg, a 50 MW power station would require approximately 600,000 tonnes of carbonaceous shale per year. Over a 35-year life, the total mineable reserve required would be 21 million tonnes.

U.S.G.S., though, is of the opinion that this resource has a greater strike length than that assumed by prior Armenian studies and believes that a strike length of eight kilometers could be possible. If this is the case, then it is possible that the total reserve could double to 28 million tonnes of resource. It is not possible at this point to determine if the necessary 21 million tonnes of

[4] Beneficiation is the process of upgrading coal by the removal of ash, sulfur or moisture.

carbonaceous shale is recoverable from the Shamut coal resource area. But it is unlikely adequate reserves could be developed because underground mining would be required and that method does not appear to be feasible. Further investigation of available information and additional geological data is required.

Our analysis above has shown that much of the reserve could very well be lost because carbonaceous layers are too thin for mining and because combining layers into mineable sections would develop a product with very high ash. In addition, a more selective mining process would adversely affect the mining economics and reduce the available resource volume. A review of the information available on the reserve suggests that a significant portion of this deposit may not be recoverable and that it would be a very low quality product because of excessive ash.

The Shamut carbonaceous shale deposit may not provide a fuel resource large enough for a 50 MW fluidized bed power station. In addition, the calorific value of the beds of carbonaceous coal, at 2,100 kcal/kg, is extremely low. The large quantity of ash generated by burning this fuel would require that the power station be located near the Shamut site in order to reduce transportation and ash handling costs to economical levels.

It would be necessary to consider environmental concerns regarding relocation of the power station in order to consider this option further. The remoteness of the Shamut site will require additional capital investment, such as a new 20-kilometer access road, to enable mining and haulage operations. Because of the remote location of this resource, the low heat content, mineability issues, and the lack of local infrastructure other resources should be considered before the Shamut site.

The Shamut site should only be considered as a carbonaceous shale deposit that would produce a product with ash in excess of 50%. No further work on this deposit is recommended until it is determined that other resource investigations have eliminated all prospects with better economic potential.

2.4 IJEVAN COAL RESOURCE ASSESSMENT

The Ijevan coal resource area is located northeast of the town of Ijevan in east-northeastern Armenia. The topography near the Ijevan coal deposit area includes steep hillsides as can be seen in Figure 2-3, below. The coal deposit has not yet been fully evaluated by the U.S.G.S. but they are of the opinion the coal field is larger than that expected by the Armenian geological professionals. In the past, the U.S.G.S. has proposed drilling in the Ijevan area but because the field is within a virgin forest area, there has been opposition from the Ministry of Environment. U.S.G.S. is of the opinion that these environmental objections can be dealt with in an appropriate fashion to allow further exploration of the Ijevan coal deposit.

Resources reported officially by the Armenian government are 9.8 million tonnes of C2 and 88 million tonnes of P classification. The U.S.G.S. determined that this deposit is geologically complex. In the current area of mapping, dips are very steep.

Figure 2-3
Ijevan Deposit Area Topography

According to the U.S.G.S.[5] the coal is of Jurassic age and has a coal bearing section thickness from 25 to 26 meters. Only one coal bed has been identified and it is about 16 to 18 meters thick. The beds dip down at a very steep angle, from 45 to 70°.

The coal outcrops on a hillside and has also been located by several shallow drill holes. The defined outcrop width is 600 meters across the hillside. There is evidence the coal could exist within a synclinal structure extending down to a depth of 500 to 1,000 meters. This structure has not been investigated as no deep drill holes have been drilled. According to Armenian geologists, there are other Jurassic coal bearing structures in Armenia that have not been investigated. Areas adjacent to this deposit also have not been geologically mapped and explored.

There is much faulting and complex structural conditions in this deposit. The visible outcrop area, where small-scale mining is taking place, displays complex faulting and is completely "sheared, squeezed, twisted and contorted, indicating a lot of tectonic deformation. The coal is sheared and broken, not really cleated" according to U.S.G.S. descriptions.

The coal was sampled by U.S.G.S. at the outcrop to develop a concept of the type and quality of the coal. Table 2-6 provides a summary of a series of 10-centimeter thick samples taken from the outcrop of the seam in the area of mining. In this sample location the total coal seam was 23 meters thick.

[5] Assessment of the Solid Fuel Resource Potential of Armenia; Brenda S. Pierce, Peter D. Warwick, and Edwin R. Landis, Open-file Report 94-149, p. 6-7, Table 1 and Table 2, Appendix 1 p. 1-4, p. 25-39.

Table 2-6
Ijevan Coal Seam Quality Sampling Data

Characteristic	ID-1	ID-2	ID-3	ID-4	ID-5	ID-6	ID-7	ID-8
Sample Interval Represented – meters	Top	5	5	5	2	2	2	2
Moisture % arb (1)	15.83	21.80	12.33	6.60	12.94	14.00	18.54	30.83
Ash arb %	70.91	47.55	15.54	26.90	23.32	48.03	40.50	21.79
Sulfur arb %	na (3)	na	na	4.77	4.12	0.90	Na	na
Calorific Value Kcal/kg mmf (2)	648	3,019	6,353	8,053	7,056	4,751	4,096	3,499
Calorific Value arb Kcal/kg	568	2,565	5,138	6,793	6,027	4,083	3,319	2,751
Volatile Matter arb %	12.27	15.05	19.13	15.65	14.58	14.05	18.97	21.37

Sample Locations	ID-1	Top of Bed	ID-5	16 Meters from top of Bed
	ID-2	5 Meters from top of Bed	ID-6	18 Meters from top of Bed
	ID-3	10 Meters from top of Bed	ID-7	20 Meters from top of Bed
	ID-4	15 Meters from top of Bed	ID-8	22 Meters from top of Bed

Note:
1: arb: as-received basis
2: mmf: moist mineral matter free basis
3: na: not available

Assuming the sampling is representative of the section being sampled, this table shows there is potential for good coal reserves because the section of the coal is rather thick. Beyond this potential, there is a fairly thick section within the seam confines that could possibly be selectively mined to produce a product with much higher calorific value. Table 2-7 below shows the average quality characteristics of the total seam as well as the higher quality section that may exist within the confines of the seam.

Table 2-7
Ijevan Seam Average and Interior Section
Coal Quality Characteristics

Quality Characteristic	Total Seam Id 2 – Id 8	Interior Section Id 3 – Id 6
Sample Interval Represented – Meters	22	14
Moisture arb (1) %	16.7	11.5
Ash arb %	32.0	28.5
Sulfur arb %	na (3)	3.3
Calorific Value mmf (2) Kcal/kb	5,260	6,350
Calorific Value arb Kcal/kg	4,380	5,510
Volatile Matter arb %	17.0	15.9

Note:
1: arb: as-received basis
2: mmf: moist mineral matter free basis
3: na: not available

If this sampling is indicative of the total deposit, then two major criteria would have been found in the Ijevan deposit that to date have not been found in the remainder of Armenia. These two important criteria are thickness combined with a potential for higher quality coal. It is of interest to note that an as-received quality as high as 5,500 kcal/kg (9,900 btu/lb.) may be mineable from within the interior of the seam over a 14-meter thickness. Reference to the limited sampling notes indicates sections 15 through 18 visibly appear to be the best sections of coal.

It may be, therefore, that a five-meter section of significantly higher quality coal exists within the confines of the coal bed. If this is the case, then one could project a 600-meter length and an 800-meter depth, and an in-bed volume of coal equal to about four million tonnes, assuming a density of 1.6 g/cm^3. Assuming the full bed thickness of 22 meters, then 17 million tonnes of resource may be in place. A 50% underground mining recovery rate would reduce the recoverable reserves in this deposit down to two million and 8.5 million tonnes, respectively, if it is economic to recover the reserves. This reserve estimate appears to correlate to the C2 reserve estimate of 9.8 million tonnes calculated by the Armenian professionals and shown in Table 2-2.

If an average calorific value of 4,400 kcal/kg could be produced by mining the 22-meter thick seam, then roughly 10 million tonnes of coal would be necessary for the power station life of 35 years. It appears there may be adequate volume in this reserve if lateral boundaries of the resource can be expanded. Lateral expansion would also be of value in reducing the depths of mining projected here to obtain the reserves needed to support the power station.

The reserve at Ijevan could only be mined by underground mining methods in order to develop reserves of any magnitude. It is expected that a mining method such as the breast-and-pillar method used in the anthracite coal sector in the Appalachian coal region of the eastern United States could be employed at this site. This is a labor-intensive method employing limited mechanized mining equipment because of the difficulty of using such equipment in such steeply dipping conditions. A method somewhat similar to this is employed at the Tkibuli mine in Georgia. Given that labor rates are currently low in Armenia, it may be economic to employ such a mining method. Because this method is no longer used in the U.S. it is difficult to project at this point in time whether such a venture in Armenia could be economic. It is known, however, that the professionals at the Tkibuli mine are of the opinion that their project, which produces a similar quality coal using a similar method, is indeed economic.

The Ijevan deposit is described as geologically complex and faulted. There is a chance the deposit has been so massively impacted by geologic events that the deposit will be very difficult to mine. Complex faulting may have destroyed the integrity of the overlying and underlying non-coal beds such that it will be impossible to economically support underground mine openings long enough to acquire the coal. Major fault structures could also reduce available coal reserves and disrupt mining efforts. There could also be water problems associated with the faults that could make mining more difficult and expensive. It is also not known how well the immediate roof structure, which has been described as a tuffaceous clay, will be able to act as a roof for mining operations.

All in all, this deposit may have adequate resources to support a 50 MW coal-fired power station but additional resources need to be found beyond the current limits of the known resource. If adequate resources do exist, two major conditions may prevent the economic mining of coal from the deposit. First, a labor-intensive underground mining method will be necessary and Armenian experience with underground coal mining techniques is non-existent. Second, the geologic conditions with the deposit may be so complex or of a nature that mining of the deposit would be too expensive. On a positive note, the deposit location is in an area that provides ready access to a labor force, available infrastructure, and rail access. At this point in time, inadequate information is available to properly assess the likely feasibility of the mining concept.

Further exploration is recommended to gather additional information about the Ijevan deposit. This deposit is likely marginally economic, as are most deposits in Armenia, but it falls within the confines of the task that has been established for this program. It is suggested that an independent mining engineer be involved to analyze the plan for additional exploration as well as to review the results of the program.

The decision of whether to go forward with this project is difficult to make. There are no guidelines established upon which a reasonable decision can be made. It is necessary that more concrete parameters be established to guide this decision-making process before additional work effort is expended. The effort to develop economic coal reserves in Armenia has shown that the reserves in Armenia are marginally economic and that the likelihood of finding low-cost economic reserves might be rather remote.

The information provided in this report and any subsequent economic analysis relative to a coal-fired power station should be employed to determine the likely cost of developing a domestic fuel resource. This information should be used to assess how more expensive or non-economic ventures would be paid for on an annual basis as well as financed for initial construction. This exercise should be used to make rational decisions concerning the country’s ability to support an expensive or non-economic energy security policy. Having an established set of guidelines would be invaluable to evaluate the Ijevan coal deposit as well as to determine if it is sensible to evaluate the Dilijan oil shale deposit any further.

CHAPTER 3
COAL DELIVERY OPTIONS AND COSTS

To date, as shown in Chapter 2, inadequate reserves of coal have been identified to support a 50 MW power station. Therefore, we are unable to provide a cost estimate based upon a coal reserve such that a reasonable level of confidence can be placed in the feasibility study for a 50 MW power station. Inadequate information exists to support the economic analysis of a coal-fired power station fuelled by domestic coal reserves. The reserves to support this power station simply are nowhere near the quantities required such that even a reliable conceptual cost estimate of coal mining and delivery can be determined.

Nonetheless, given the information available an estimate of the range of costs for a power station can be estimated. The potential for importing coal from known suppliers within the region to provide a more reliable imported coal cost estimate can also be determined.

3.1 COST ESTIMATE FOR DOMESTIC COAL

Armenia has low quality coal occurring in thin coal seams under geologically complex conditions. The coal deposits investigated so far by Armenian and U.S.G.S. professionals show small deposits with coal resources that hold little promise to develop mineable economic reserves. The coal seams tend to be thin and erratic in nature. These conditions generally preclude underground mining methods. The use of underground mining methods is also restricted because the complex structural conditions that exist include intense faulting and folding. For deposits that have been explored adequately enough to assess the resources from a mining perspective, it is expected that surface mining along coal outcrop areas would be a satisfactory method. Because seams explored so far are thin and the coal dips down rather quickly in these deposits, surface mining would generally be restricted to surface contour-haulback methods.

Surface contour-haulback methods open up a narrow strip of coal along the outcrop of the coal so coal seams can be mined for market. Often the widths of the pits to mine coal such as that found in Armenia are narrow and range from 30 to 90 meters in width, depending on the seam thickness, quality of the coal, overburden thickness, ground slope, and mining economics. Of the conditions observed so far in the coal resource areas, the ground slope increases upward in the area of coal outcrop such that the width of the mining pit around the outcrop is even more limited. If conditions are found to exist wherein the ground slope approximates the dip of the coal so that a relatively thin overburden thickness exists over a broad area, then significant resources of coal could be a candidate for reserves to support a coal-fired power station. Unfortunately, these conditions have not yet been found to exist in the hilly conditions of Armenia.

Therefore, it will be necessary to find an extensive outcrop length and/or thicker coal seams to develop the needed reserves. Consequently, a reasonable assumption for the likelihood of low-cost reserves for a coal-fired power station in Armenia is a contour-haulback type of surface mine. Because reserves of this type of mine are dependent upon a fairly narrow pit width that is influenced by maximum economic stripping ratios, the cost of coal produced at a typical mine site can be roughly estimated.

In the U.S.G.S. evaluation of the Antaramut coal deposit, a mining engineer was commissioned to develop a pre-feasibility study for one million tonnes of coal. This study[1] concluded that a contour-haulback surface mining method would be feasible and developed a cost estimate based on local mining equipment, resources, and labor. Local assistance in developing costs for this study was provided by the Republic of Armenia State Committee on Reserves. In Hagler Bailly's opinion, this work is the most reasonable estimate for planning purposes. The costs estimated by the U.S.G.S. are summarized in Table 3-1.

Table 3-1
Theoretical Minimum Delivered Domestic Coal Costs Per Tonne (1)

Total Mining Cost	$15.11
Proposed Profit	$3.77
Total Mine Cost Delivered on Rail	$18.88

Note:
(1): Source: p. 33 U.S.G.S report referenced in footnote.

These costs represent a small mining operation wherein production is expected from contour-haulback and auger mining operations producing a total of about 40,000 tonnes per year. Larger mining operations would have lower fixed and unit variable costs and as such could be more economic. However, with the need to increase reserves it is likely that stripping ratios would increase and mining costs would subsequently increase as well. Given that a better geologic model upon which to develop a theoretical mining cost is not available, this is the best assessment for the lower mining cost estimate, for the time being.

These costs were calculated in the fall of 1999 and converted to U.S. dollars at a rate of 540 drams per U.S. dollar and can be assumed to be appropriate for a constant dollar analysis. Given the likely mining conditions found to date and potential for new coal deposits in Armenia it is reasonable to estimate this cost represents the lower boundary for the range of costs that could be expected for Armenian coal production. Because adequate coal reserves to support a 50MW power station have not been identified, only a FOB-rail price range of $18 to $50 per tonne can be employed to predict the likely cost of fuel for the power station. A positive economic rate of return for the power station can be expected to lie within the lower portion of this range of costs.

[1] Potential Mineability and Economic Viability of the Antaramut-Kurtan-Dzoragukh Coal Field, North-Central Armenia: A Prefeasibility Study, Douglas W. Huber and Brenda Pierce.

In order to evaluate delivered coal prices, it is assumed that coal would be delivered from a location such as the Antaramut area that has local rail access. We can then project the rail transportation cost components can then be projected. The rail haulage cost per tonne-kilometer, for bulk materials, were quoted by Armenian transportation officials as equivalent to $0.024, assuming a 540 dram exchange rate.

It is assumed that the power station would be located in Hrazdan because this location provides significant reductions ($20 million) in the construction of the power station at this site. The Hrazdan power station complex provides pre-investment from other facilities that can be used by a coal-fired fluidized bed power station. Economic analysis shows that the initial capital investment of the power station is the single most important variable in the economic viability for the project; thus, the reduction of capital for the power station guides the site selection.

The rail haulage distance from the Antaramut project to the Hrazdan power project is estimated to be about 300 kilometers. With the $0.024 per tonne-kilometer unit haulage cost assumption, the transportation cost to Hrazdan from the Antaramut project is $7.20 per tonne. By assuming the FOB $18.00 to $50.00 per tonne cost to produce coal as a reasonable cost of coal in Armenia, the Hrazdan delivered theoretical cost of coal is $25 or $57 per metric tonne. Given the available information about the coal deposits, this range of figures cannot, at present, be narrowed further.

To estimate coal quality, information from the Antaramut coal deposit was used. The reserve quality shown in Table 2-3 was used and equal thickness of both seams was assumed. During mining, it is assumed that two inches of non-coal material is added to both the seam top and bottom such that the ash content of the coal is increased. This is a normal occurrence in mining operations and is dependent upon the characteristics of the geologic contact between coal and non-coal materials as well as the skill of the mining workers.

Considering these resources and the effects of mining dilution on thin seams, we recommend a coal with the characteristics shown in Table 3-2 is employed as a typical domestic coal product specification delivered to a coal-fired power station (until more specific information becomes available). It must be understood that this is a theoretical coal quality and represents the best available information to approximate typical deliveries, if they were economic. The coal is delivered in the run-of-mine, or raw, state and that it has not been beneficiated in any way.

Table 3-2
Recommended Assumptions for the
Quality of Domestic Coal Delivered to an Armenian Power Station

Quality Characteristic	Units	Value
Calorific Value – As Received Basis	Kcal/kg	4,100
Ash Content – As Received Basis	%	50
Moisture Content – As Received Basis	%	5.1
Sulfur Content – As Received Basis	%	3.0
Volatile Matter – Dry Ash Free Basis	%	25.5

3.2 COST ESTIMATE FOR IMPORTED COAL

The efforts to date to find a domestic coal reserve base in Armenia have not identified a reliable resource. As the domestic coal potential dwindles, an alternative that appears reasonable is the development of a foreign coal source or a foreign power source supplied by foreign coal. One source within the region is the Georgian coal mine, Tkibuli, near the city of Kutaisi in western Georgia.

The Tkibuli mine is actually a complex including the Imereti, Mindeli, and Western 2 underground mines. There are older mines on the property that have been in production for several decades. Between the years 1960 and 1985, production ranged from 1.2 to 1.4 million tonnes per year but decreased to 700,000 tonnes by 1991. The three mines referenced have A, B, and C1 coal reserves of about 90 million tonnes while there are future resources of about 230 million tonnes, some of which may be mineable and economical.

This mine appears to have at least 60 million tonnes of coal reserve that could be sold on the open market. They currently are facing an extremely lackluster market due to the regional economic problems. The mine is working a rather thick section of coal on the flank of a synclinal (bowl-shaped) coal deposit. Future production capacity of the mine has been estimated to be between 500,000 and 1,000,000 tonnes per year but currently is selling less than 50,000 tonnes per year. The total coal seam thickness being mined is approximately 15 to 30 meters thick and is separated by up to five non-coal intervals which range from one to 3.5 meters thick.

Current mine plans call for the production of coal necessary to support a 125 MW coal-fired power station. Station construction is visualized such that commercial operations could commence in year 2003. The mine employs a modified caving method with continued mining operations down-dip from mined-out operations. They are said to require about $20 million in capital in order to restart the mine at levels to support the 125 MW power station. The capital required includes equipment for operations such as conveying, ventilation, rail haulage, drilling, electrical, and hoisting.

The produced coal has a lower-calorific value of 4,000 - 4,500 kcal/kg, a sulfur content of 1.0 – 1.5%, and an average ash content of 30 - 35%, on an as-received basis. It might be reasonable to expect this coal could be sold FOB at the mine for a price of roughly $30 to $35 per tonne.

The cost of delivered Tkibuli coal to the Hrazdan site can be estimated because the coal can be delivered by rail from Tkibuli to Hrazdan. The exact condition of the rail along the route is not known but it is operable and used, for the most part. There are sections where the rail bed requires improvement. The rail distance from Tkibuli to the Armenian border near Sadakhlo, Georgia is estimated at 260 kilometers and the distance from that point to Hrazdan is estimated to be 360 kilometers. The Georgian bulk cargo rate is $0.017 per metric ton-kilometer and the Armenian rate is $0.024 per metric tonne-kilometer. The Georgian component of rail transport would be $4.42 and the Armenian component would be $8.64 for a total estimated freight cost of $13.06 per tonne. No international taxes or custom fees are included in this estimate.

The likely cost of purchasing coal from the Georgian Tkibuli mines is $30 to $35 and the rail freight is $13 for a total delivered cost FOB Hrazdan of $43 to $48 per tonne. If one assumes the lower figure of $43 per tonne and the calorific value of 4,300 kcal/kg, this coal, on a delivered energy basis at the plant would cost $10.00 per million kilocalories or $2.44 per million British Thermal Units. This coal could be considered as somewhat expensive due to the lower quality of coal involved but still represents a reasonable alternative to respond, in some part, to the energy security issue.

The quality of coal from the Tkibuli mine is similar to the quality of coal that might be achievable from Armenian mines. It is possible that the coal could be beneficiated at Tkibuli but beneficiation tests as well as mine investment are necessary to produce coal from this complex. Given the potential to produce coal from Tkibuli for an Armenian coal-fired power station, as part of an alternative energy source, or strategic back-up for local coal, assuming one million tonnes of production per year is possible, the Georgian plant has the potential to support a 150 MW power station. If this alternative appears to be a reasonable way to diversify energy sources to enhance energy security, power costs might be cheaper if a power station were constructed at the Tkibuli mine site and power were shipped by wire rather than resorting to the higher costs of coal transport.

The possibility of using Tkibuli coal in a Georgian power station could also realize improved economics if a power station site near rail at the border near Sadakhlo was deemed to be feasible. The cost of coal (lower range) at that location could be significantly reduced to the $35 per tonne level, rather than the $43 per tonne level. This option is obviously worth considering but requires suitability for the power station siting.

The Tkibuli mine in Georgia should be considered as a source of coal for an Armenian coal-fired power station; thus, it is recommended a pre-feasibility study be developed to analyze this option in more detail. Furthermore, the option of placing the power station at the mine site in Georgia and transmitting the power to Armenia should also be reviewed in an attempt to improve the economics of the facility.

3.3 POWER PLANT SITING OPTIONS

Power station siting options within Armenia to date include the Hrazdan and Vanadzor sites. The site at Vanadzor has been discounted because the site does not meet space requirements, does not have well developed support infrastructure and has no need for electricity/heat demand in that area. In addition, this site has since been sold to a private Russian entity. No other options have been considered for the siting of the 50 MW power station.

One technique often used to enhance the competitiveness of a power station is to site the power station near the mine in order to reduce the transportation cost component of the delivered fuel price. This technique is even more desirable as the ash and moisture content of the coal increase. Because much of the coal evaluated in Armenia appears to be of high ash, it is possible that a mine-mouth power station may make economic sense. The difficulty at this point in the investigation of coal resources is that adequate reserves have not been found to justify the siting of a power station in a mine-mouth fashion.

In order to provide some level of guidance on this issue, a site such as Antaramut could provide an acceptable quantity of coal upon which a mine-mouth power station could be justified. The economic alternatives for the price of delivered coal, comparing truck haulage to a mine-mouth power station versus rail haulage to an off-site power station is shown in Table 3-3. A coal heat content of about 4,100 kcal/kg is assumed a rail haulage distance of 300 kilometers, and a coal freight transportation price of US$0.024 per tonne kilometer for this analysis.

As can be seen in Table 3-3, the preliminary derived differential cost of delivered coal is estimated at US $7.20 per tonne with a delivery volume of 308,000 tonnes per year.

Table 3-3
Mine-Mouth Power Station
Economic Analysis Differential
Delivered Coal Cost Comparison

Parameter	Hrazdan Site	Antaramut Mine Mouth Site
Capital Cost Saving Due to Plant Siting	$20,000,000	$0
Tonnes Delivered Per Year	308,000	308,000
Rail Transportation Costs/Tonne	$7.20	$0
Rail Transportation Cost/Year	$2,220,000	$0
Haulage Savings over a 35-Year Life	$0	$77,700,000
Capital Cost Savings	$20,000,000	$0
Total Savings	$20,000,000	$77,700,000
Net Present Value of Savings (a)	$20,000,000	$21,400,000
Net Present Value Differential		+ $1,400,000

Note:
(a) Assumes a 10% discount rate.

Table 3-3 shows the net present value break-even haulage distance, under these conditions at current rail bulk haulage rates, is about 300 kilometers. Considering the capital cost increase to site the power station at a new virgin location is at least the $20 million estimated by Burns and Roe, the break-even haulage distance is 281 kilometers for this quality of coal. A 3,500 and a 5,500-kcal/kg coal would have a NPV saving of $5.0 million and -$4.0 million at a 10% discount rate, and break even haul distances of 240 and 377 kilometers, respectively. This information can be used as a rough guide to determine the likely impact of alternate plant siting options for differing grades of coal in Armenia. There are other siting related issues such as proximity to the existing electricity transmission lines, supply of water, transportation access, environmental impact, etc. that must be considered in order to properly analyze siting options. It will be necessary to evaluate each opportunity on a case by case basis as the analysis will depend upon any potential future solid fuel supply source.

In order to analyze, from an economic perspective, raw fuel deposits that appear to have higher price levels, it will be necessary to determine to what extent subsidization will support the mine and/or the power station. It will be necessary to analyze power station economics with a range of delivered coal prices so that the range of economically acceptable delivered coal prices can be determined. Acceptability must be determined based on the outlook for the potential to attract either development or private bank funding for both the mining and the power generation complexes. This analysis will provide the limits of acceptability for mine development based on likely mining costs for the coal deposit being considered. Any projects considered that have likely mining costs above the bank acceptability economic limits will have to be based upon subsidization concepts, which, as discussed in chapter 4 of this report, require conceptual definition and acceptance by Armenian authorities and development aid agencies.

CHAPTER 4
THE IMPLIED COST OF ENERGY SECURITY THROUGH DOMESTIC OR REGIONAL COAL RESOURCES

The efforts to date to find adequate coal resources in Armenia to support a coal-fired power station have not yet been able to identify adequate coal resources to fire a 50 MW power station. The work so far in all deposits investigated determined that possibly one million tonnes of coal may exist in economically feasible quantities. This is far short of the nine to ten million tonnes necessary for a 50 MW power station over 35 years. Some of the solid-fuel quality found in Armenia is of such a low quality that even larger quantities of coal are necessary to support a power station.

The reality of the energy situation facing Armenia for this domestic fuel strategy is that Armenia must attract financing for both the power station and the mine. Evaluations to date have only considered the cost of developing the power station, which is appropriate, because the capital cost component of the mine is included through a depreciation component in the unit cost of the fuel delivered to the power station. Nonetheless, adequate capital must also be attracted to build both the mine and the power station. Because there is no information upon which to estimate the capital necessary to build a mine, it is difficult to determine what the capital costs might be without having the coal reserve defined. From experience, the cost to develop a mine with adequate capacity could easily range anywhere from \$30 to \$100 million.

Because of the nature of development bank involvement in Armenia, it will be necessary to attract financing from western banks who are willing to risk investment in an Armenian mine and power station. The mine and power stations must be able to economically return a profit that exceeds investment risk levels to attract foreign financing. Thus, these projects must either stand alone and make an adequate profit or they must be subsidized. Given Armenia's current and projected economic woes, it is likely that the projects must stand alone and be profitable in order to attract foreign financing.

4.1 DOMESTIC OPTIONS TO PROVIDE ENERGY SECURITY

Only one option that has not been investigated in detail, Ijevan, remains as the only resource that may produce domestic coal reserves sufficient for an Armenian coal-fired power station. If Ijevan, for whatever reason, can not provide the necessary reserves, then it appears that all possibilities for coal-fired power generation from domestic coal reserves will have been exhausted. The option at that point in time is to review the Dilijan oil shale resource and consider locating a power station near those reserves. If the decision to analyze this shale resource is made, the compatibility of the fuel, given the best available quality information, from a mining perspective, should be analyzed to first ensure the fuel is satisfactory for the fluidized bed power station.

If domestic coal reserves could be found to provide fuel for a power station, there is an economic cost that must be paid because a coal-fired power station in this region is not the most economic choice for power generation. It is widely accepted that generation of electricity is regionally much cheaper with hydro and natural gas than with coal. Specific studies are necessary for the power station and fuel supply options being analyzed but generally speaking, for a 125 MW power station, a coal-fired power station can cost from $35 to $60 million additionally each year in contrast to a gas-fired power station. This information is based upon Hagler Bailly's prior comparative economic analyses conducted in the region and assumes a domestic supplier with a coal quality similar to Armenian coals to a mine-mouth power station.

4.2 REGIONAL OPTIONS TO PROVIDE ENERGY SECURITY

As the Armenian exploration work program appears to be nearing completion and the desire to achieve a greater measure of energy security still exists, it is recommended that a parallel program be initiated at this point in time to continue this quest on a wider horizon. If Armenia simply does not have the coal resources to support a power station of significant size, then one of the next best alternatives remaining is to develop coal resources in nearby countries wherein a reliable supply, market, and economic relationship can be expected. At this point in time, there appears to be only the coal resource at Ijevan that may have the potential to provide the necessary coal for a 50 MW power station. However, Ijevan has difficult geologic conditions that may preclude mineability or the possibility of economic mining.

The search for potential resources should be widened to include nearby foreign coal resources that could potentially provide additional energy security. This program should be initiated while the last investigation into the remaining Armenian coal fields are concluding in order to conserve time and begin evaluating other options. Initially, review of historical production statistics by country should be initiated to determine the capability of established mines or exploited reserves to become a potential supplier. If this level of information does not exist, then the effort would have to begin at the "grass-roots" level of exploration. It is recommended that the exploration team be advised by an independent specialist who can evaluate mining, transportation, and fuel utilization options as the work commences to assist in determining priorities and optimizing the potential for rapid success.

One alternative that is known to exist is the Tkibuli coal mine located in Georgia as discussed in the prior chapter. This resource may provide value because much investment has already been made in the mine and limited capital investment is required in order to re-establish acceptable production capability. Compared to the need to find and develop coal resources in Armenia, this is an attractive possibility. The capital injection required to locate coal reserves, conduct necessary analysis and feasibility studies, and construct a mine with the capacity of the Tkibuli mines in today's economy can easily range from $100 to $500 million. The Tkibuli mines require an investment in the neighborhood of $20 million to revitalize production. They appear to have the potential of supporting a 150 MW power station. This option could support a larger power station than is currently being considered and may possibly benefit from a higher quality coal if additional beneficiation capital is invested.

If it is assumed the Tkibuli mine produced coal for shipping to Armenia, as discussed in Chapter 3, the lower cost estimate of fuel is projected to be at least $43 per tonne, FOB power station at Hrazdan. Given this assumption and based on prior regional studies, the annual cost for a 125 MW power station versus a natural gas-fired power station in Armenia will carry an additional economic cost of about $50 to $85 million per year. This is the economic cost of providing additional energy independence using a coal-fired 125 MW power station. This unit cost will increase, on a unit power basis, for smaller power stations and decrease for larger facilities. As mentioned in Chapter 3, there are some reasonable options requiring review that could reduce this cost.

The comparatively high economic cost of a coal-fired power station is greatly dependent on the capital investment required for the plant as well as the low calorific content of the coals found so far in this region. If high quality economic coal can be found near Armenia, then the differential economic costs between coal and natural gas-fired power stations will narrow. Nonetheless, as shown above, it appears the most economic alternative for Armenia is to solve the natural gas supply problem in a fashion that provides additional energy security.

Hagler Bailly recommends that the value of developing domestic energy sources be analyzed to determine what annual cost of domestic resource subsidy is acceptable. This information should be used as a guide to determine how this cost will be managed and how future exploration programs should be targeted, rather than spending to explore every possible deposit.

CHAPTER 5
RECOMMENDATIONS

The coal reserves of Armenia and the likely cost of coal at a power station have been analyzed within this report in an effort to support the development of a 50 MW power station in Armenia. The overall purpose of this program is to find coal reserves and develop a power station to generate more energy security and independence for Armenia. The following provides Hagler Bailly's recommendations following a review of where the program stands based on over five years of work. This chapter summarizes the primary recommendations and provides a basic discussion regarding the recommendations.

Chapter 2 analyzes the coal deposits evaluated so far by the U.S.G.S. and concludes that adequate coal resources appearing economically mineable in sufficient quantities to support a 50MW coal-fired power station have not been identified. The overall quantity and quality of carbonaceous shale in the Shamut deposit is likely inadequate for a 50MW coal-fired power station. The only coal deposit remaining that may hold any promise is the Ijevan deposit located in northeastern Armenia.

> **All deposits explored to date do not have the potential to provide an economically reliable coal resource for a 50 MW power station. Hagler Bailly recommends that only the Ijevan coal deposits be explored by the U.S.G.S. to determine if a potential coal resource may occur. If coal is not found in sufficient quantities then evaluation concerning the use of low quality oil- shale resources of Dilijan would be the next likely domestic candidate. It is necessary that an analysis of available information from a mineability perspective be conducted to determine if the expense of additional exploration funds in the future appears warranted.**

The exploration efforts to date have not identified a solid fuel resource providing the necessary fuel resource volume or economics to support a power plant. Future work will have to focus on solid fuel deposits that are less desirable because of lower heat and higher ash content and poorer economic value. It is necessary to realize the program has almost reached the threshold where exploration will begin to focus on solid fuel resources of significantly less value and higher cost. It is required, therefore, to revisit assumptions and guidelines established for this program relative to meeting energy security goals.

> **Hagler Bailly recommends that information provided in this report and any subsequent economic analysis relative to a coal-fired power station are employed to analyze the likely economics and cost of developing a potential fuel resource. If the quality and cost of a solid fuel resource delivered to the power station forces the**

plant to have a negative internal rate of return and this return will not be satisfactory to any financier, then further exploration is not warranted. This analysis should be used to determine how non-economic or expensive mining ventures would be financed and subsidized on an annual basis in order to support the economics of a coal-fired power station. This exercise should allow rational decisions concerning Armenia's ability to support an expensive energy security policy by setting financial limits dependent on Armenia's financial capability, necessity to attract capital, and donor tolerance.

Guidelines should then be developed for this project to ensure precious donor funds are not poorly employed. These guidelines would be invaluable to evaluate the Ijevan coal deposit and to determine if it is sensible to evaluate resources such as the Dilijan oil shale deposit any further. The purpose of these guidelines would be to establish what level of economic feasibility is required for future solid fuel deposits. This measure can be presented in terms of net present value along with the internal rate of return, and the annual maximum subsidy support capability.

The efforts of the Armenian Coal Exploration and Resource Assessment Program have appropriately focused to date upon locating the best available coal reserves in Armenia. One candidate, Ijevan, appears to hold promise of a decent quality coal with adequate reserves that may be economic. Other known remaining domestic resources include the Dilijan oil shale deposit located northeast of the Sevan Lake. Analyzing low-grade fuel deposits any further will require investigating fuel resources with ash content greater than 50%. Ash content greater than this magnitude will dictate a mine-mouth power station and a much more meaningful ash management plan if ventures are to be economic.

Hagler Bailly recommends that a maximum technical capability description be prepared for a fluidized-bed power station to guide explorers in evaluating sites, such as solid fuel resources with ash greater than 50%, prior to expenditure of further funds. Because it will now be necessary to evaluate more marginal domestic fuel reserves, guidelines and an economic analysis model should also be developed to guide decisions related to economic analysis of fuel resources and power station feasibility. Since capital and operating costs for a standard 50 MW fluidized bed power station were investigated before, there is a need to update this information for cases where fuels have higher ash content, lower calorific value, and higher price assumptions. This model and the guidelines should be prepared to allow explorers the capability to evaluate a fuel reserve so that they can predict the likely economic performance of a specific deposit. In this way, likely economics can be reviewed to determine if they are reasonable enough for further exploration efforts to be pursued. This model should be developed to allow evaluation of both mine site and the Hrazdan power station location options.

The coal resources identified during the coal exploration program were reviewed to determine if a mining cost could be estimated, reasonable for the type of domestic reserves identified, and appropriate for use in economic analyses concerning the coal-fired power station. Because adequate information concerning economic coal reserves is not available, this task can not be accomplished with any reasonable degree of certainty. Nonetheless, because the reserves identified so far all appear to be amenable to a contour-haulback mining method, the costs developed by the U.S.G.S. are assumed to be a reasonable estimate of the likely lower range of economic mining costs. The delivered cost of coal was estimated by using current unit bulk cargo rates for rail.

> **Hagler Bailly concludes that inadequate information exists to generate reliable cost and fuel quality estimates for confident economic analyses of a 50 MW coal-fired power station. A theoretical delivered FOB rail cost of $25 to $57 dollars per metric tonne can be assumed as a reasonable cost for domestic coal delivered to a power station at Hrazdan. The $57 upper price is an expert estimate based on uneconomic exploration projects in the US. Similarly, a theoretical calorific value of 4,100 kcal/kg, an ash content of 50%, a sulfur content of 3.0%, moisture content of 5% (all as-received basis), and a DAF volatile matter content of 25% are recommended as the domestic design fuel quality characteristics for a coal-fired power station. This estimate incorporates the best available information at this time.**

The efforts to develop a domestic coal resource have not yet "borne fruit" and it is possible that after the Ijevan exploration is complete, adequate coal resources may not be found. Because the value of greater energy security is important for Armenia, it is worthwhile to consider coal resources beyond the Armenian border. These resources might provide more energy independence through mutual reliance upon economic goals with Armenia's neighbors while also encouraging private financing opportunities. Although this alternative is not as desirable as having domestic coal reserves, it is a viable alternative when with having a single source of natural gas.

> **Hagler Bailly recommends a research program for information on potential coal suppliers and coal resources in the countries bordering Armenia wherein mutual international benefit could result. Opportunities to develop a source of supply from a foreign coal deposit for an Armenian station or to develop power from a foreign mine-mouth coal-fired power plant should be investigated.**

> **To initiate expansion beyond Armenian borders, the Tkibuli mine in Georgia should be considered as a viable option because a mine exists, reserves have been identified, and the Government of Georgia desires to improve the coal-mine driven economy in the Tkibuli region. In addition, a transportation system is in place and a situation exists where dependent reliance between supplier and buyer would act as a long-term cohesive agent. This alternative should be fully investigated, developed, evaluated, and presented to the Government of Armenia as a formal energy security**

option against which other options can be compared. With the Government of Armenia's approval, a formal plan and proposal could be developed for the Government of Georgia and to solicit private interest groups. This effort would provide the program with a definite show of success.

Chapter 4 demonstrates that the economic cost of a coal-fired versus a natural gas-fired power station is rather high, at $50 to $85 million annually, and therefore should be a serious consideration for a country with limited financial resources. This information is provided as a catalyst to begin asking the question of what energy independence is worth in Armenia. The fact that no significant coal resources have yet been found leads to the possibility that only the low heat content oil shale resource at Dilijan may provide the possibility of adequate domestic quantities of solid fuel that could be used to fire a fluidized bed power station.

Hagler Bailly recommends that information be generated from alternate power generation cases that show the annual cost of alternative independent energy sources, so that decisions can be made about the tradeoff between the cost and value of energy independence for Armenia.

Although adequate reserves have not been found to economically support the financing of a mine for the power station, it could be possible if either the Ijevan coal or possibly the Dilijan shale oil deposits are deemed to be suitable sources. About one million tonnes of economic reserve appear likely at Antaramut and could be a fairly good-sized local supply source. To date, no focus has been exerted on developing a climate in Armenia to attract foreign investment in the mining sector. If this overall project is to be successful, it will be necessary to attract foreign mining companies and financiers to Armenia. Because Armenia does not have adequate funds to explore and develop a mining property, it will be necessary that USAID or another donor fund these work tasks to the point at which foreign mining investors will be attracted. In discussions with foreign professionals working in the mining industry of Armenia, they find it very difficult to work because they can not even generate a letter of credit so that supplies or equipment, which have to be purchased from abroad, can be procured. A new set of mining policies and regulations as well as environmental regulations need to be developed in order to enable Armenia to attract foreign capital into the mining sector.

Hagler Bailly recommends action to begin preparing acceptable regulations and policies for the mining industry so that foreign mining companies and their financiers will be attracted to Armenia. It will also be necessary to ensure that appropriate environmental safeguards are instituted.